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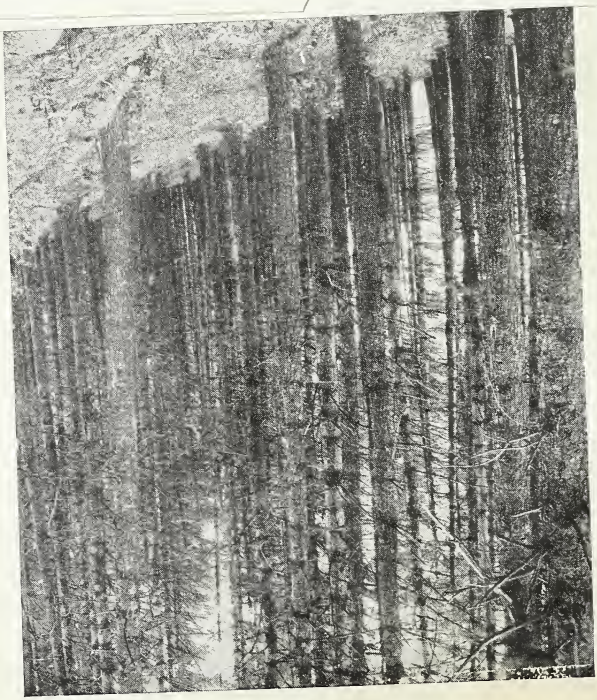
the crown and roots prevents sprouting. The bushes should be hung up where the roots will quickly dry out or they may continue to live.

Cultivated black currants should be eradicated within a radius of at least 1 mile of white pines. Large plantings of this currant may be a serious menace to pines at distances up to 2 miles. Pine owners should look upon wild currants and gooseberries as dangerous weeds and uproot them whenever found. In sections where these bushes are naturally few, going over the ground once will probably be sufficient to bring a pine crop to maturity. In places where the bushes are numerous, it will be necessary to reexamine the ground after five years and eradicate any missed or newly grown bushes.

The cost of eradicating wild currants and gooseberries will vary according to the difficulties encountered in doing the work, such as the density of underbrush, number of bushes, and character of ground. In the eastern United States the cost of currant and gooseberry eradication work has averaged 25 cents per acre on about 3,450,000 acres, while on an experimental area of 8,000 acres in northern Idaho it averaged $1.63 per acre. Compared with the value of the white pines protected the cost of applying control measures is reasonable and profitable.



WHITE PINE
IS PROFITABLE
IF PROTECTED FROM BLISTER RUST

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STOP
THE
DESTRUCTION OF WHITE PINE

Fig. 6.—[illegible] white pine being killed by blister rust

White pines both large and small are killed by blister rust

White-pine blister rust is a forest-tree disease, apparently of Asiatic origin. It was unknowingly brought into this country from Europe and is now present in the New England States, New York, New Jersey, Pennsylvania, Michigan, Wisconsin, Minnesota, and Washington. In Canada it occurs in the Provinces of British Columbia, Ontario, Quebec, Prince Edward Island, New Brunswick, and Nova Scotia. It was first discovered in North America in 1906. To-day in New England and New York one-tenth of the white pines over large areas are diseased and in many small areas from 50 to 100 per cent of the pines are dead or dying from the rust.

Any white pine [1] (five-needle pine) is subject to blister-rust attack. The fungus kills the bark, causing the death of the tree, as illustrated above. The white pine in this picture is 14 inches in diameter breast high and 40 feet in height. The portion of the tree above the trunk canker is dead, and as the disease works downward the remaining live portion is gradually being killed. Pines of all sizes are readily killed by the rust. The small trees succumb quickly, but larger ones die more slowly, because it requires a longer time for the fungus to reach and girdle stems of larger diameter.

[1] The names and range of the five-needle pines in North America are as follows: White pine (*Pinus strobus* L.), Newfoundland to Pennsylvania, along the Appalachians to Georgia, west to eastern Iowa and Minnesota, and in Canada from Lake Winnipeg to northern shore of Gulf of St. Lawrence and Newfoundland; western white pine (*Pinus monticola* Dougl.), Montana and southern British Columbia to Washington, Oregon, and California; sugar pine (*Pinus lambertiana* Dougl.), Oregon through California into lower California; ayacahuite pine (*Pinus ayacahuite* Ehrenb.), Mexico to Guatemala; Mexican white pine (*Pinus strobiformis* Engelm.), Arizona, New Mexico, and northern Mexico; limber pine (*Pinus flexilis* James), Rocky Mountains, Alberta to Chihuahua, South Dakota, Nebraska, Texas to Oregon and California; white-bark pine (*Pinus albicaulis* Engelm.), British Columbia and Alberta, south to Wyoming, west to Pacific Coast States; foxtail pine (*Pinus balfouriana* Murr.), California; bristle-cone pine (*Pinus aristata* Engelm.), Colorado and New Mexico west to California.

8—5364

LOOK
FOR
CURRANTS AND GOOSEBERRIES

Fig. 7.—Wild gooseberry bush growing among white pine

Blister rust is controlled by the eradication of currant and gooseberry bushes

The blister-rust disease is so widespread in this country that it can not be eliminated. Locally, it can be controlled effectively. Local control means the protection of individual stands or areas of white pine and is possible because of vulnerable points in the life of the fungus.

The fungus can spread to pine only by means of the fall spores produced on currant and gooseberry plants, and these spores are so delicate and short-lived that under average field conditions pines growing more than 900 feet from diseased bushes are not appreciably damaged. Therefore, under normal forest conditions practical local control can be accomplished by eradicating all currant and gooseberry bushes within 900 feet of the pine to be protected.

The European or cultivated black currant (*Ribes nigrum*) is more susceptible to blister rust than other currants and gooseberries. It becomes infected at distances up to 100 miles or more from diseased pine and causes local centers of infection, from which the rust spreads to other currants and gooseberries and to white pine. The ease with which this currant becomes diseased makes it an important agent in the long-distance spread and local establishment of the rust in disease-free regions.

On account of its menace to white pine several States have declared the cultivated black currant a public nuisance. The United States Department of Agriculture is opposed to its growth in the United States and recommends its elimination.

The growing of white pine either by planting suitable denuded areas or through natural reproduction should be encouraged and the trees protected against blister rust by the eradication of currants and gooseberries. Wild currants and gooseberries grow more or less abundantly in association with white pine, so that field conditions are favorable for the spread of the rust. These bushes grow slowly and reestablish themselves slowly from seed. They vary in size from seedlings to bushes several feet in height and are found in many soil types from swamp to hillside.

ACT
PROMPTLY
BY UPROOTING THESE BUSHES

Fig. 8.—Blister-rust crew uprooting wild currants and gooseberries

Systematic eradication of currants and gooseberries guarantees effective protection of white pines

Experience shows that it is necessary to know the different species of currants and gooseberries and to use systematic methods of work to secure their thorough eradication. Haphazard methods are lacking in thoroughness and give poor results. If the bushes are plentiful a crew will do the work well and cheaply; if scarce, one or two trained men can do equally good work provided they use systematic methods.

A crew is usually composed of five men working abreast, closely followed and supervised by a foreman, who finds and pulls any missed bushes. The crew men work 6 to 12 feet or more apart, depending principally upon the density of underbrush and the abundance of currant and gooseberry bushes. They systematically go over the ground in parallel strips, the edge of each strip being marked with small pieces of paper dropped by the end man, so that no ground will be skipped or needlessly reworked. The small bushes are readily uprooted by hand and the large ones by use of a grub hoe. Thoroughness in removing the crown and roots prevents sprouting. The bushes should be hung up where the roots will quickly dry out or they may continue to live.

Cultivated black currants should be eradicated within a radius of at least 1 mile of white pines. Large plantings of this currant may be a serious menace to pines at distances up to 2 miles. Pine owners should look upon wild currants and gooseberries as dangerous weeds and uproot them whenever found. In sections where these bushes are naturally few, going over the ground once will probably be sufficient to bring a pine crop to maturity. In places where the bushes are numerous, it will be necessary to reexamine the ground after five years and eradicate any missed or newly grown bushes.

The cost of eradicating wild currants and gooseberries will vary according to the difficulties encountered in doing the work, such as the density of underbrush, number of bushes, and character of ground. In the eastern United States the cost of currant and gooseberry eradication work has averaged 25 cents per acre on about 3,450,000 acres, while on an experimental area of 8,000 acres in northern Idaho it averaged $1.63 per acre. Compared with the value of the white pines protected the cost of applying control measures is reasonable and profitable.

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U. S. Department of Agriculture

WHITE PINE
IS PROFITABLE
IF PROTECTED FROM BLISTER RUST

Fig. 1.—Maturing white-pine crop on untillable land

Perpetuation of the white pines is of national and regional economic importance

Five hundred and fifty million dollars ($550,000,000) represents the value of the present white and sugar pine timber crop as it stands in the forest. The future of this important resource in the United States is threatened by the white-pine blister rust, a disease that kills the living trees. Blister rust can and must be controlled in order to save the white pines and make possible the growth of a new crop of these valuable timber trees.

Wherever they grow, from Maine to California, these white pines constitute the cream of the forest. Their value far outstrips that of the associated species, making possible clean logging and good utilization. Large wood-using industries employing thousands of men and distributing millions of dollars every year in wages and supplies are dependent for their support upon the white pines.

Foresters advise that the maintenance of the white pines in our forests is a matter of great importance and one of national concern. These trees are known and valued because of their rapid growth, excellent wood, high yield, and adaptability to forest management. In the Northeastern States white pine is grown in rotations of from 40 to 60 years. In many sections the principal income from the land is derived from the white pine, which yields a profit of $5 to $10 per acre per year. With such an essential and valuable resource at stake, affecting both national and regional economic welfare, it is important that Federal, State, and private agencies cooperate in a united effort to accomplish control of the white-pine blister rust.

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
and the States of
California, Connecticut, Idaho, Maine, Massachusetts, Michigan, Minnesota, Montana, New Hampshire, New York, Oregon, Pennsylvania, Rhode Island, Vermont, Washington, and Wisconsin cooperating.
MISCELLANEOUS CIRCULAR No. 40

By J. F. MARTIN, Pathologist

Washington, D. C., July, 1925
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GOVERNMENT PRINTING OFFICE

ACT

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BY UPROOTING THESE BUSHES

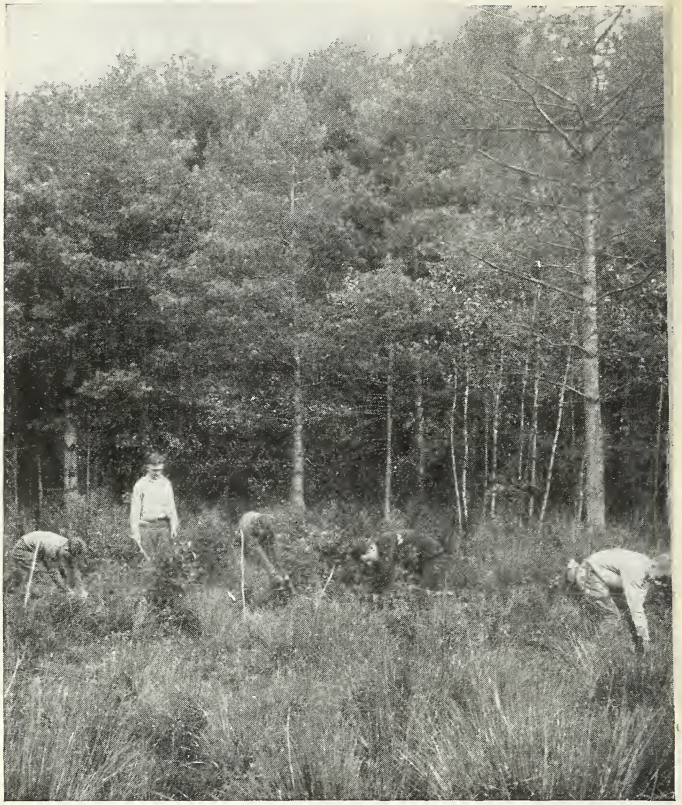

Fig.

Fig. 8.—Blister-rust crew uprooting wild currants and gooseberries

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HOW BLISTER RUST SPREADS AND DESTROYS WHITE PINE

Fig. 2.—White pine with blister-rust canker producing spring spores which infect currants and gooseberries

Fig. 3.—Wild gooseberry bush producing fall spores which infect white pines

Fig. 4.—A white-pine stand before blister-rust damage becomes noticeable

Fig. 5. The effect of blister rust a few years after attack

From white pines the disease spreads only to currant and gooseberry leaves. It can not go from one pine to another

Blister rust is a disease of white pines and currant and gooseberry plants. It is caused by one of a group of plants called fungi. Some fungi, like the common molds, live on dead material, while others, like the blister rust and chestnut blight, exist as parasites on living plants. They reproduce themselves by means of spores. The spores of fungi correspond to the seeds of other plants and have the same function.

The blister-rust fungus infects the bark of white pines through the needles. In the second or third year after attack, the diseased bark gradually swells and forms a canker, the edges of which vary from yellowish green to orange in color. This ripening of the canker usually is completed in the spring of the third year after infection takes place, and then from April to June orange-yellow blisters about the size of a navy bean burst through the diseased bark, as shown in the picture above. These blisters are sacklike outgrowths that contain millions of the tiny orange-yellow fungous spores or seeds. These spores are called spring spores, to differentiate them from the summer and fall spores produced later in the year on the leaves of currants and gooseberries. When ripe these sacs break open, and the spring spores are scattered far and wide by the wind.

After the spores have disappeared from the canker the ruptured bark dies. The mycelium, or roots of the fungus, continues to grow into the healthy bark bordering the canker, and each spring produces new blisters or sacs of spores. Thus, each canker, and there may be a large number on a tree, is a source of new spores each year until the limb or trunk on which it is located has been killed. Cankers frequently develop on the trunk from infected needles, but most of them develop on the branches, where infected needles are more numerous, and then grow back toward the trunk.

From currant and gooseberry leaves the disease spreads to white pines

Early in the spring the spores from diseased white pines come in contact with the leaves of wild and cultivated currants and gooseberries and, after germinating like ordinary seeds, grow into the leaf tissue. They can not grow upon other kinds of plants. The different species of currants and gooseberries are among the first shrubs in leaf in the spring and vary in the ease with which they become infected. The European or cultivated black currant is more easily infected and produces a larger number of fall spores than any other species.

The presence of the blister-rust fungus on currant and gooseberry bushes is not noticeable until it has grown for two or three weeks in the leaf tissue. Then small orange-yellow pustules appear in more or less abundance on the under side of the leaves. These pustules break open and liberate a mass of summer spores, which spread the disease on currants and gooseberries from leaf to leaf and bush to bush, producing new infections. This is repeated several times during the growing season and increases locally the amount of infection on currants and gooseberries. From late June until the foliage dies, brownish hairlike outgrowths of the fungus appear on the under side of the diseased leaves. These outgrowths produce the fall spores that infect white pines.

The spring, summer, and fall spores of the blister rust serve to spread and perpetuate the fungus. The spring spores are long-lived and spread the rust from pines to currants and gooseberries for long distances. The summer spores are also long-lived and spread the disease locally on currants and gooseberries. The fall spores are short-lived and spread the rust from currants and gooseberries to white pines for comparatively short distances. The short infecting range of the fall spores makes it possible to control the rust locally by the eradication of currants and gooseberries growing within a short radius of white pines.

White-pine stands appear healthy for at least three years after blister-rust attack

Blister-rust attack is very deceptive in its early stages on pine because of the lapse of three years between infection and the maturity of the resultant canker. The fall spores from diseased currant and gooseberry leaves come in contact with the needles of white pines and cause infections through the leaf tissue. The fungus requires about three years to grow down through the needles into the bark and produce the characteristic blisters or sacs of spring spores that again start the rust on currant and gooseberry leaves. Each year the spores from near-by currant and gooseberry bushes cause new infections on pines. The resulting damage accumulates with each succeeding wave of infection, and the trees gradually become severely diseased.

A white-pine stand may become heavily infected and yet for several years afterwards look normal and healthy. Severe damage may become suddenly noticeable at the end of the 3-year period during which the cankers are maturing. On the other hand, the first wave of infection may be very light, causing but few cankers, and marked damage will not be noticed until the disease increases in volume as a result of successive waves of infection.

Do not acquire a false belief in the freedom of a pine stand from blister-rust attack because it looks healthy. Remember that blister-rust is a disease which works in a pine for a long time under cover of a healthy external appearance and shows its effect only when the damage is an accomplished fact. Prompt eradication of the currant and gooseberry bushes on pine lands will prevent healthy trees from becoming infected and permit natural restocking with the healthy seedlings that grow up after each seed year.

Damage to white-pine stands increases each year and becomes more and more noticeable as the cankers mature

The effect of the disease upon pines begins to be noticeable about three years after infection takes place and becomes more apparent with the continued development of the rust.

Diseased young trees under 10 years of age often have a stunted bushy growth and yellowish color, but others do not materially change their normal appearance until they begin to die. On older trees the first indications of damage appear as scattered dead and dying branches commonly called "flags." From these diseased branches the fungus grows back into the trunk. After the trunk is girdled the portion of the tree above the canker dies. The tops frequently break off at the point of girdling, thus destroying the value of the trees a considerable time before they are entirely dead. The fungus, however, continues to grow downward through the healthy bark and gradually kills the remaining live portions of the trees. Blister-rust cankers occurring on the trunks greatly retard the growth of white pines. In some instances large trees have been killed quickly by the death of all their branches from blister-rust cankers. These different types of damage may be found in severely infected pine stands and are characteristic of blister-rust attack.

The death of white pines already weakened by blister rust is hastened by the secondary attacks of fungi and insects, and the dead trees are quickly destroyed by these agencies. Squirrels and other rodents feed upon white-pine bark diseased with blister rust and often remove most of the infected bark of the cankers they feed upon. Rodent work is easily recognized by the bare white wood of cankered areas from which the diseased bark has been recently chewed. Later these barkless areas become streaked with dry pitch and are grayish black in color. Such areas on white-pine trees usually indicate the presence of blister rust.

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